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Some DTPA Extractable Micronutrients in Different Hill Forest Soils of Chittagong Region, Bangladesh

Md. Akhtaruzzaman[1,*], K.T. Osman[1] and S. M. Sirajul Haque[2]
[1]*Department of Soil Science, University of Chittagong, Chittagong-4331, Bangladesh*
[2]*Institute of Forestry and Environmental Sciences, University of Chittagong, Chittagong-4331, Bangladesh*

Abstract

DTPA (Diethelene-triamine pentaacetic acid) extractable micronutrients of surface soil samples from six different locations of Cox's Bazar and Chittagong districts were studied. All the soils under study were sufficient in DTPA extractable Fe, Mn and Cu contents. The available Zn contents in soils of Dulhazara, Chengchhari and Faissakhali under study were also above the critical limit while soils at Fulchhari, Hasnabad and CU were deficient in available Zn. The study also showed that DTPA extractable Fe content had the significant and positive relationships with clay and soil organic carbon. On the hand, negative and significant relationship was observed between extractable Mn and soil pH while DTPA extractable Zn and Cu were positively and significantly correlated with soil organic carbon of the studied area.

Key Words: hill forest soils, DTPA extractable micronutrients status, correlation

Introduction

Micronutrients are those elements which are essential to the completion of the life cycle of biological systems, but which are required in relatively small amounts. Plant micronutrients generally included in this group are boron (B), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo) and zinc (Zn). Although chlorine (Cl) and cobalt (Co) are also micronutrients, their supply in most forest-ecosystems is usually sufficient. The range of Co in soil is between 0.8 and 12 mg kg^{-1} (Kabata-Pendias 2011) while Cl content varies between 91 and 486 mg kg^{-1} (Yuita et al.1983) and their deficiencies are rarely observed in plants (Kabata-Pendias 2011).

Micronutrient cycling in forest ecosystems is a complex series of processes. The processes such as weathering, mineralization, fertilization, atmospheric input etc. are involved in micronutrients addition to soils while harvesting, leaching, biological immobilization, sorption, precipitation, soil erosion etc. are responsible for the removal of micronutrients from soils. Distribution and bioavailability of soil micronutrients like Fe, Mn, Cu and Zn were mainly controlled by biological cycling, anthropogenic disturbance and leaching and strongly affected by land uses (Jiang et al. 2009), forest type and soil properties (Sheng and Bao 2009). In most forest ecosystems, litterfall and throughfall were the important sources ensuring the balanced supply of micronutrients in the top soils for the growth of forests (Sheng and Bao 2009).

In the surface soil, micronutrient availability depends on

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Corresponding author: Md. Akhtaruzzaman

Department of Soil Science, University of Chittagong, Chittagong-4331, Bangladesh
Tel: 880-1711471838, Fax: 88-031-2606014, E-mail: akhtarsoilcu@gmail.com, akhtarcu@yahoo.com

soil pH, nature and content of organic matter, adsorptive surfaces of clay particles, and other physical, chemical, and biological conditions in the rhizosphere. Plant cycling, the turnover of organic matter and lower soil pH may strongly contribute to enhance soil available micronutrient levels in forest soils (Jiang et al. 2006).

The hill forests in Bangladesh are facing severe degradation due to encroachment and illicit removal of timber and firewood, improper forest management system and lack of motivation among local population relating forest conservation (Hassan 1995). Forests degradation causes the top soil erosion, resulting in the depletion of organic matter and soil nutrients. Declining forest cover enhances surface soil erosion through extensive surface runoff caused by heavy monsoon rain. As a result, the soil material at the lower depth is exposed to the surface (Zheng 2005). Gafur (2001) also reported that the continuous loss of soil reduced soil fertility.

Micronutrients are essential for plant growth. Lack of any one of them in the soil can limit plant growth, even when all the other essential nutrients are present in adequate amounts (Potash and Phosphate Institute 1983).The micronutrients are important for gene expression, biosynthesis of proteins, nucleic acids, growth substances, chlorophyll and secondary metabolites, metabolism of carbohydrates and lipids, stress tolerance, etc. (Rengel 2003; Gao et al. 2008). The study could help to know the status of micronutrients and also to restore soil fertility and productivity of hill forests.

In spite of the importance of micronutrients in plant growth, little research has been done on their concentrations in soils of different hill forest ecosystems of Bangladesh. The objectives of this study were: (i) to assess the status of DTPA (Diethelene-triamine pentaacetic acid) extractable Fe, Mn, Cu, and Zn in soil and (ii) to explore the relationships between micronutrients and soil properties.

Materials and Methods

The present investigation was conducted in different forest soils of hilly regions of Chittagong and Cox's Bazar districts because, forest disturbance and increased population pressure in these areas accelerated soil erosion and reduced soil fertility.

The hill soils are underlain by tertiary sediments of unconsolidated and partially unconsolidated beds of sandstones, shales and conglomerates of mid-Miocene to Pliocene age (Krishnan 1956; Wadia 1957).

The micronutrient status of surface soils was assessed from six different forest sites of Cox's Bazar and Chittagong districts. The four sites were Dulhazara, Chengchhari, Fulchhari and Faissakhali under Cox's Bazar district and the other two sites like Chittagong University (CU) and Hasnabad were under Chittagong district. Each forest site was covered with different tree species consisting of evergreen and semi evergreen trees. In most of the sites studied, the forest, land, biodiversity, wildlife and environment were found to be adversely affected mostly by anthropogenic activities. The general description of the study area was presented in Table 1. The soil color was dark yellowish brown to dark grayish brown which is moderately well-drained.

Soil samples were collected randomly from the soil depth of 0～15 cm at the above six locations and each site belonged to 6 replications.

The collected soil samples were air dried, gently ground to pass through a 2-mm mesh sieve and then stored in clean polybags.

Particle size distribution of the soils was determined by

Table 1. General description of locations under study

Location	Longitude	Latitude	Dominant Tree Species Local name (Scientific name)
Dulhazara	21°41´09N	092°05´20E	Garjan (*Dipterocarpus* spp.), Jam (*Syzygium* spp.)
Chengchhari	21°58´32N	092°11´14E	Garjan (*Dipterocarpus* spp.), Chapalish (*Artocarpus chaplasha*)
Fulchhari	21°37´34N	092°02´53E	Garjan (*Dipterocarpus* spp.)
Faissakhali	21°44´37N	092°05´32E	Garjan(*Dipterocarpus* spp.), Jam (*Syzygium* spp.)
Hasnabad	22°49´45N	091°43´11E	Garjan (*Dipterocarpus* spp.), Daki Jam (*Syzyzium* grande)
Chittagong University (CU)	22°28´45N	091°47´46E	Acacia (*Acacia auriculiformis*)

hydrometer method (Day 1965). pH was measured in soil-water suspension (1:2.5) using a glass electrode pH-meter. Organic carbon, organic matter and total nitrogen were by wet-oxidation method of Walkley-Black (1934) and micro-kjeldahl's method (Jackson 1973), respectively. Cation exchange capacity (CEC) was determined after extraction with 1N ammonium acetate solution (Black 1965). Available Fe, Mn, Cu, and Zn in soil were determined by DTPA (diethylene-triamine pentaacetic acid), extraction method (Petersen 2002). The Correlation Co-efficient with parameters was done using Minitab (1996).

Results

Soil properties

The clay content, soil organic carbon (SOC), soil pH and cation exchange capacity (CEC) of soils under study were shown in Fig. 1 to Fig. 4. The soils were poor in clays. Lower clay content was in Hasnabad and higher was in Faissakhali. These soils were acidic in nature (lower mean soil pH was found in CU and higher were in Hasnabad). On average basis of organic carbon, CU soils had the lower content of organic carbon while Dulhazara showed the higher amount of organic carbon. The average CEC was lowest in CU soil and highest was in Dulhazara soil.

DTPA extractable iron (Fe)

Table 2 showed that the DTPA extractable Fe in soils ranged from 82.00 mg kg^{-1} in Hasnabad to 126.23 mg kg^{-1} in Dulhazara.

Table 2 showed that DTPA extractable Fe was positively and significantly correlated with clay and soil organic carbon.

Considering 4.5 mg kg^{-1} soil as the threshold value of DTPA-extractable Fe (Lindsay and Norvell 1978), all the studied soils had sufficient amount of available Fe content.

DTPA extractable manganese (Mn)

DTPA extractable Mn varied from 15.33 mg kg^{-1} soils of Hasnabad to 28.48 mg kg^{-1} in soils of Dulhazara.

Taking 3.0 mg kg^{-1} DTPA extractable Mn in soils as the

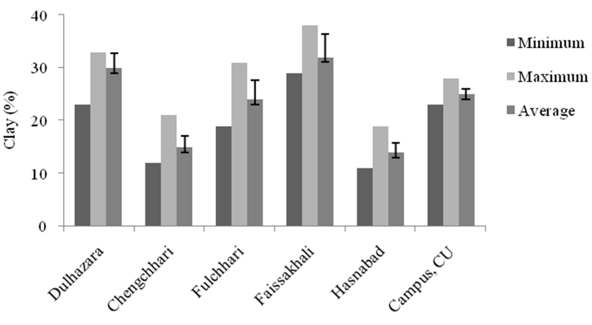

Fig. 1. Clay contents of soils of different forest ecosystems under study.

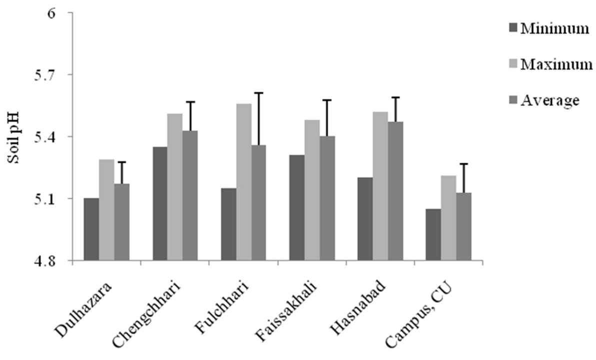

Fig. 3. Soil pH of different forest ecosystems under study.

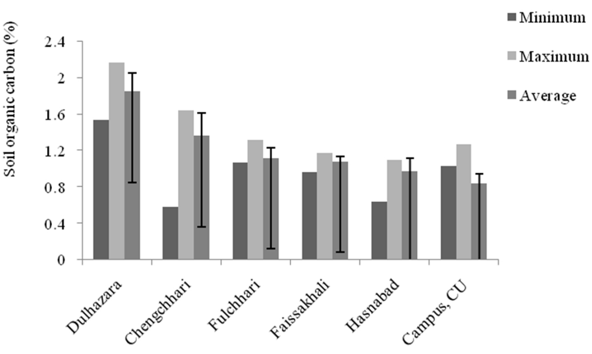

Fig. 2. Soil organic carbon of different forest ecosystems under study.

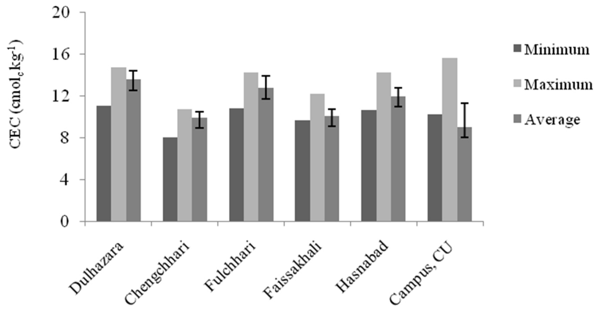

Fig. 4. Cation Exchange Capacity (CEC) of soils of different forest ecosystems under study.

Table 2. Some DTPA extractable micronutrients of soils under study

Location	Available micronutrients (mg kg^{-1})			
	Fe	Mn	Zn	Cu
Dulhazara	$126.23^{a}\pm1.64$	$28.48^{a}\pm1.36$	$1.28^{a}\pm0.102$	$1.23^{a}\pm0.083$
Chengchhari	$86.60^{a}\pm1.61$	$18.10^{b}\pm1.57$	$0.88^{b}\pm0.289$	$0.79^{a}\pm0.100$
Fulchhari	$95.00^{a}\pm1.49$	$25.52^{b}\pm0.803$	$0.63^{b}\pm0.025$	$0.98^{b}\pm0.016$
Faissakhali	$103.00^{b}\pm1.79$	$19.65^{c}\pm0.512$	$0.85^{c}\pm0.045$	$0.96^{ac}\pm0.040$
Hasnabad	$82.00^{c}\pm2.04$	$15.33^{b}\pm0.531$	$0.78^{a}\pm0.020$	$0.55^{b}\pm0.065$
Chittagong University (CU)	$92.80^{a}\pm1.74$	$24.80^{ac}\pm0.262$	$0.74^{b}\pm0.046$	$0.53^{c}\pm0.031$

Data presented are mean values±standard deviation. Values with different lowercase (a～c) letters are significantly different at different land-use systems ($p < 0.05$).

critical limit (Anonymous 1976), it may be safely concluded that the studied soils have adequate quantities of available Mn. The negative and significant relationship was found between extractable Mn and soil pH only (Table 2).

DTPA extractable zinc (Zn)

DTPA extractable Zn ranged from 0.63 mg kg^{-1} in Fulchhari soil to 1.28 mg kg^{-1} in Dulhazara soil (Table 2).

Taking 0.8 mg kg^{-1} as the critical limit of DTPA extractable Zn (Lindsay and Norvell 1978), extractable Zn contents in soils of Dulhazara, Chengchhari, Faissakhali forest sites were above critical level while the soils of the rest three sites (Fulchhari, Hasnabad and CU) had the Zn concentrations below the above threshold value (Table 2).

Table 2 showed that DTPA extractable Zn had the positive and significant relationship with soil organic carbon of the studied sites.

DTPA extractable copper (Cu)

The results showed that available Cu ranged from 0.53 mg kg^{-1} in Chittagong University (CU) soil to 1.23 mg kg-1in Dulhazara soil (Table 3). All the soils are found to be adequate in available Cu as 0.2 mg kg^{-1} is considered the threshold value for available Cu (Lindsay and Norvell 1978). The available Cu was significantly correlated with the soil organic matter content under study (Table 3).

The study showed that Dulhazara forest soil contained highest contents of all the extractable micronutrients studied (Fe, Mn, Zn and Cu) than that of other forest sites (Table 2).

Table 3. Correlation coefficients between DTPA extractable micronutrients and soil properties

Soil properties	Extractable micronutrients			
	Fe	Mn	Zn	Cu
Clay	0.715*	0.459	0.129	0.394
Soil organic carbon	0.678*	0.205	0.782*	0.662*
Soil pH	−0.301	−0.696*	−0.144	−0.147
Cation Exchange Capacity	0.238	0.123	0.167	0.385

* indicates significance at 5 % level.

Discussion

Higher concentrations of Fe in acid soils of Bangladesh were documented by other workers (Gafur et al. 2004; Akter et al. 2012). Gafur et al. (2004) also reported that Fe can also come from the mineral sources such as goethite, and hydroxy-interlayered vermiculites (HIV) and smectites (HIS) present in these hill soils.

Available Fe showed significant correlation with clay and organic matter content which is in agreement with the results reported by Follet and Lindsay (1970), Datta and Ram (1993), Khan et al. (1997).

The variations in available Mn in soils of different forest sites depend on a number of factors, of which pH is the most important. Alloway (2008) reported that the availability of Mn is strongly influenced by soil reactions in rhizosphere. Available Mn showed significant correlation with soil organic matter and soil pH which is in consistent with the results reported by other researchers (Hossain et al. 2009; Khan et al. 1997).

Clay and organic matter has a positive effect on extractable Zn in soils (Gupta et al. 2000). Tisdale et al. (2003) reported the availability of Zn increased with increasing of soil organic matter content. This may be due to the formation of organo-mineral complexes with organic matter and metallic cations which protect available Zn from leaching.

The results showed that soils at Fulchhari, Hasnabad and Chittagong University (CU) under study were deficient in available Zn. Rahman et al. (2012) observed very low levels of Zn in different acid soils of Bangladesh. Chesworth 1(991) also reported that Zn deficiency in soils is common as Zn is considered as an element of low mobility in soils. Shaheen et al. (2007) reported that acid soils are rich in free iron and aluminum oxides which fix the available Zn in soil and make it unavailable to the plants.

The significant relationships of available Zn with soil organic carbon are in agreement with the results reported by Kumar et al. (2001).

The values of available Cu soils under study seemed to be lower than those reported on floodplain of Bangladesh. Hossain et al. (2009) noted that DTPA-extractable Cu ranged between 2 and 13 mg kg^{-1} in floodplain soils of Bangladesh. Hodges (2015) reported relative low Cu levels in severely weathered, leached and acid soils.

Katyal and Sharma (1991) and Khan et al. (1997) reported that the soils with an aquic moisture regimes were richer in available Cu. Kabata-Pendias and Pendias (2000) reported that the mobility of copper was associated with the transport of organic material since there is a greater affinity of Cu for organic compounds and they also suggested that mobility and leaching loss of available Cu increased with the decreasing soil pH from the surface soil.

The significant correlation of DTPA-extractable Cu with soil organic matter is in accordance with the earlier reports of Tripathi et al. (1994) and Chatterjee and Khan (1997).

The significant correlation between extractable Cu and soil organic matter might be attributed to the formation of highly stable copper-humate complexes and to their increasing dissolution that occurred in the soils (Di Palma et al. 2007).

Dulhazara forest soils contained higher contents of extractable micronutrients compared to the soils of other forest sites. This might be explained as relatively high amounts of clay, organic matter and low soil pH favour the highest concentrations of extractable Fe, Mn, Zn and Cu in the soil at Dulhazara forest site.

The solubility and availability of micronutrients is largely influenced by clay content, soil pH, soil organic matter, cation exchange capacity and other soil properties. Soil organic matter in surface soils of forest ecosystems plays the vital role in retention and availability of extractable micronutrients as well as also in protecting them from leaching. Most of the trace elements increase in solubility as organic matter content increases (Jiang et al. 2009; Eneji et al. 2003). However, soil organic matter does not only mobilize microelements but immobilizes them as well.

In the areas under investigation, different types of activities such as logging, litter collection as fuel, habitat destruction seemed to be more frequent and as a result, organic residue turnover, soil aggregate stability, nutrient availability and distributions were disturbed as well as their relationships were also affected.

Conclusions

The results of the present study revealed that soil characteristics such as clay, soil organic carbon, soil pH and cation exchange capacity played the important roles in availability of micronutrients in the surface soils of different forest sites under investigation. The study also suggested that organic matter is an important source for the supply of available Zn in surface soils of the forest areas. Most of the forests are facing degradation due to removal of trees without sufficient reforestration by humans which also affect the litterfall, organic matter turnover and soil properties. The deficiency of micronutrient especially available Zn in the forest soils under study is likely to be intensive in the near future if detrimental interferences could not be controlled immediately. Local people awareness programs may be taken for the protection of tree species and maintenance of undergrowth vegetation which might increase litter inputs in soils and improve nutrient status in the forest soils. In some cases, proper fertilization may be required to meet the micronutrient demand in forest soils. Further study regarding micronutrient concentrations in subsurface soils is needed.

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